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Late Jurassic ammonites from the Tetori Group in Arimine area of Toyama Prefecture, northern Central Japan*

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富山県有峰地域の手取層群から産出したジュラ紀後期アンモナイト化石

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富山県有峰地域の東坂森谷の上部ジュラ系手取層群九頭竜亜層群有峰層から，*Perisphinctes* (*Perisphinctes*) cf. *ozikaensis* と，属種不明ではあるがおそらく *Dichotomosphinctes* sp. と思われるアンモナイト，２個体が産出したので記載する。*Perisphinctes* (*Perisphinctes*) *ozikaensis* は宮城県牡鹿半島の石巻市牧浜から最初に記載された（Fukada, 1950および; Sato, 1962; Takahashi, 1969）あと，同県気仙沼市西舞根（旧唐桑町「貝浜」；加藤ほか，1977）から，また*P.* sp.が山口県東部の岩国市美和（Sato et al., 1986）から発見されているが，今回の*Perisphinctes* (*Perisphinctes*) cf. *ozikaensis* は手取層群からは初めての報告である。*Dichotomosphinctes* 属のアンモナイトは富山市南部の桐谷からも報告されている（Sato,1962)。これらのアンモナイトの産出は，富山県内の九頭竜亜層群の年代を追認するために重要であるとともに，手取層群と日本における同時代のアンモナイトを産出した地層との対比に有益であると考えられる。

キーワード：ジュラ紀後期，手取層群，九頭竜亜層群，有峰層，東坂森谷，アンモナイト
Key words: Late Jurassic, Tetori Group, Kuzuryu Subgroup, Arimine Formation, Higashisakamori-dani, Ammonites

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Introduction

Two ammonites were recently collected from the upper Jurassic marine deposits of the Tetori Group in Arimine area of southern Toyama Prefecture in northern Central Japan. They are *Perisphinctes* (*Perisphinctes*) cf. *ozikaensis*, and probably immature whorls of *Dichotomosphinctes* sp.. *Perisphinctes* (*Perisphinctes*) *ozikaensis* has been hitherto known from near Makinohama in Ishinomaki City (Fukada, 1950; additional reports by Sato, 1962; Takahashi, 1969), and Nishimone in Kesen-numa city (Kato et al., 1977), both of Miyagi Prefecture, and *P.* sp. from Miwa in Iwakuni city in eastern Yamaguchi Prefecture (Sato et al., 1986) in Japan. The clastic deposits of the Tetori Group widely crop out in the northern part of Central Japan, and were divided into the Kuzuryu, Itoshiro and Akaiwa subgroups in ascending order by Maeda (1961). This classification is generally accepted up to now. The Tetori Group overlies unconformably older metamorphic, igneous and sedimentary rocks in the Hida Belt of Inner zone of Southwest Japan.

The group is dated Middle Jurassic to Lower Cretaceous, but its precise starting age of deposition is difficult to determine because of the lack of index fossil from the lowest part. The Kuzuryu and Itoshiro subgroups are dated late Bathonian to middle Oxfordian and early Tithonian to early Barremian respectively by ammonites (Sato and Westermann, 1991; Sato et al., 2003; Sato and Yamada, 2005; Goto, 2007; Matsukawa et al., 2007; Sato, 2008; Sato et al. 2008). The Akaiwa Subgroup is dated basically Hauterivian to Aptian on the basis of occurrences of bivalves, spores, pollens and freshwater plants (Isaji, 1993; Umezu and Matsuoka, 2003; Kubota, 2005). In this paper, *Perisphinctes* (*Perisphinctes*) cf. *ozikaensis* is described for the first time from the Tetori Group. Its occurrence is important to confirm the age of the Kuzuryu Subgroup in Toyama Prefecture, and useful to correlate the Tetori Group with corresponding strata in Japan.

The specimen TOYA- Fo-3016, *Perisphinctes* (*Perisphinctes*) cf. *ozikaensis*, was collected by one of the co-authors (M.G.) in 1992. Another one (TOYA-Fo-3017), probably immature whorls of *Dichotomosphinctes* sp., was collected by Mr. Hideo Takayanagi in Toyama City in 1989. All the specimens are housed in the Toyama Science Museum.

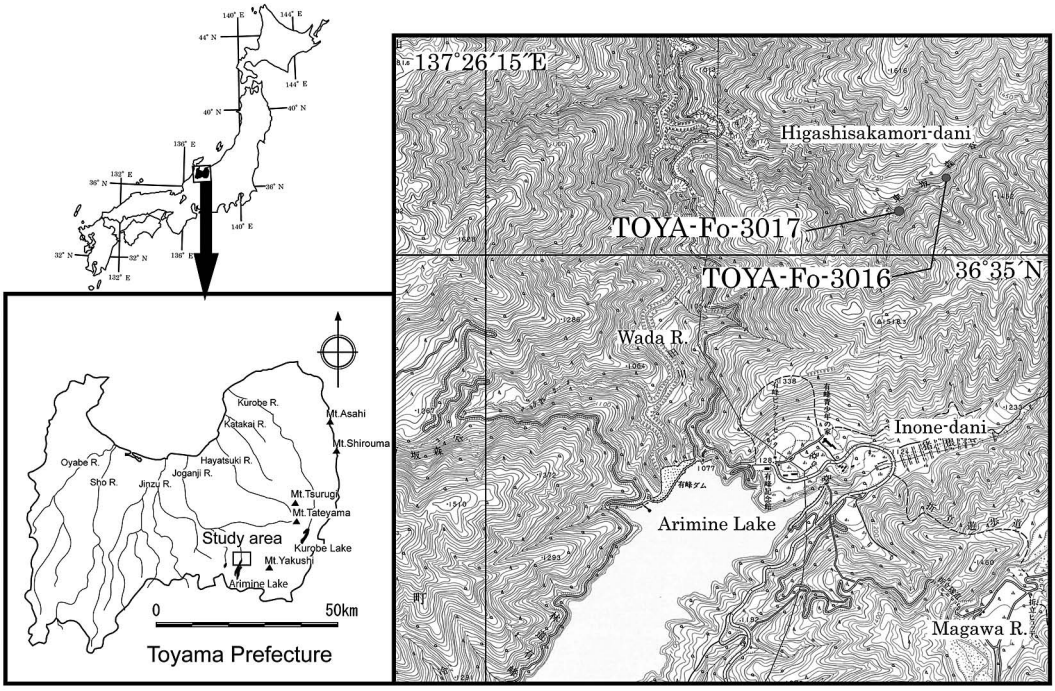

Fig 1. Locality of ammonites from the Kuzuryu Subgroup of the Tetori Group in Arimine area, southern Toyama Prefecture, Central Japan. Dots represent ammonite localities. TOYA-Fo-3016 and 3017 are register numbers (Toyama Science Museum) of the specimens collected from the cited localities.

Geological setting

The Tetori Group distributed in Arimine area of southern Toyama Prefecture is stratigraphically divided into the Higashisakamori, Nagatogawa and Atotsugawa Formations in ascending order, which are judged to belong to the Kuzuryu, Itoshiro and Akaiwa subgroups respectively (Kawai and Nozawa, 1958). Nozawa and Sakamoto (1960) used different names for the same formations, as Lower, Middle and Upper Tetori Group respectively, but in this paper we adopt Kawai and Nozawa's subgroup-level classification.

The Kuzuryu Subgroup of Arimine area is subdivided into the Magawa and Arimine Formations in ascending order. These formations crop out sporadically along the Magawa River, Higashisakamori-dani and Inone-dani ravines (Fig. 1). The Magawa Formation, (Ma-gawa sandstone and conglomerate by Maeda and Takenami, 1957), includes angular to sub-angular pebble to cobble conglomerates with lip-up clasts of sandstone and mudstone. The conglomerates consist of clasts of chert, sandstone, slate and granitic rocks in coarse-grained sand matrix (Maeda and Takenami, 1957). Some trigonian bivalves are found in coarse-grained sandstone of this formation (Maeda and Kawabe, 1966). The Arimine Formation, which was named by Kawai (1955), is composed mainly of mudstone with parallel laminations and intercalations of thin sandy siltstone and fine sandstone, and conformably underlain by the Magawa Formation. Some bivalves including *Myophorella* are found in sandy mudstone and coarse-grained sandstone of this formation. This formation is marine, and dated basically middle Oxfordian to early Kimmeridgian mainly by ammonites and radiolarians. A probably upper Jurassic ammonite, disputably assigned to *Perisphinctes* (*Kranaosphinctes*) *matsushimai*, was discovered from the black mudstone of the Arimine Formation of the Higashisakamori-dani ravine (Matsukawa et al., 2008). Middle Oxfordian to early Kimmeridgian radiolarians were reported from the siltstone in unlined tube-like trace fossils of the Arimine Formation at an adjacent locality of the same ravine (Hirasawa and Kashiwagi, 2008; Kashiwagi and Hirasawa, 2010). This formation corresponds to the upper part of the Kuzuryu Subgroup in age.

Systematic Description of Ammonites

Abbreviations: D, diameter; UD, umbilical diameter; H, whorl height; W, whorl width; UD/D, ratio of umbilical diameter to diameter.

Perisphinctes (*Perisphinctes*) cf. *ozikaensis* Fukada

Fig. 2

Cf. 1950, *Perisphinctes* (*Perisphinctes*) *ozikaensis* Fukada, p.212, Pl.I, Fig. 1.

Material: Register number TOYA-Fo-3016; An outer mold of large fragmentary whorls, collected by M. Goto, from Arimine (precise locality shown in Figure 1).

Measurements (in cm.): D (preserved largest whorls) ca. 17; UD ca. 10.5 (UD/D ca. 0.6); H (preserved last whorl) >5; W unknown (compressed and only one side preserved).

Description: Coiling very evolute (UD/D probably more than 0.6), inner whorls overlapped by next whorl only on the ventral part; shallow constrictions sporadically visible, parallel to the ordinary ribs; ribbing rectiradiate, sharp, inclined slightly backward at the umbilical border; secondary ribs not observable, but presumably branched off at the ventral margin; number of primary ribs per half whorl about 22 or 23; ribs change shape to widely spaced swells on the preserved last whorl, probably rapidly at some time of development (at the beginning of the last preserved whorl). Other features are unknown because of poor preservation.

Observation: The specimen at hand is an outer mold of two whorls and a small part of the last whorl. Such

important criteria for identification as the characters of inner, immature whorls and the whorl section of any stage of development are not available. Therefore definitive identification is impossible, but in general outline, it can be said that the specimen belongs certainly to the genus *Perisphinctes* s.l. However, fragments of still larger whorls seen outside the inner whorls show distant wavy swellings, instead of sharp ribs, which indicate that the change of ribbing occurred sometime in the adult stage. The change seems to have taken place suddenly as seen in the preserved whorl fragments. It is therefore acceptable that this specimen should be placed in the group of *Perisphinctes* with sudden change of ribbing, or *Perisphinctes* s.s. or *Ampthillia.*

Comparisons: *Perisphinctes* s.s. has been discovered from dispersed sites of Japan. *Perisphinctes* (*Perisphinctes*) *ozikaensis* was discovered from the sea bottom near Makinohama in Ozika Peninsula (Fukada, 1950). It is a large but strongly deformed outer cast, measuring about 50 cm along the long axis of deformed whorls. The ornamentation is quite similar to that of the present specimen, though the size seems much larger. If the present specimen is completely preserved its size should be about 25cm or more, then the ribbing at the comparative size could be similar. *Perisphinctes* aff. *ozikaensis* was also reported by the same author (Fukada, 1950, Pl.I, Fig. 2) from Hirohama, Oginohama, near the former locality, but its ribbing is distinctively different from the holotype of *Perisphinctes ozikaensis.* It might be close to *Lithacoceras* sp. (Takahashi, 1969, Pl. 14, Fig.4). Another *Perisphinctes* s.s. *ozikaensis* was discovered from Kaihama in Karakuwa (Kato et al., 1977) which is rather well preserved in black sandy shale, measuring about 45 cm in longer diameter (long axis of elliptically deformed specimen). The formation from which it was discovered is the Mone Formation of the Karakuwa Group, corresponding to the Oginohama Formation mentioned above.

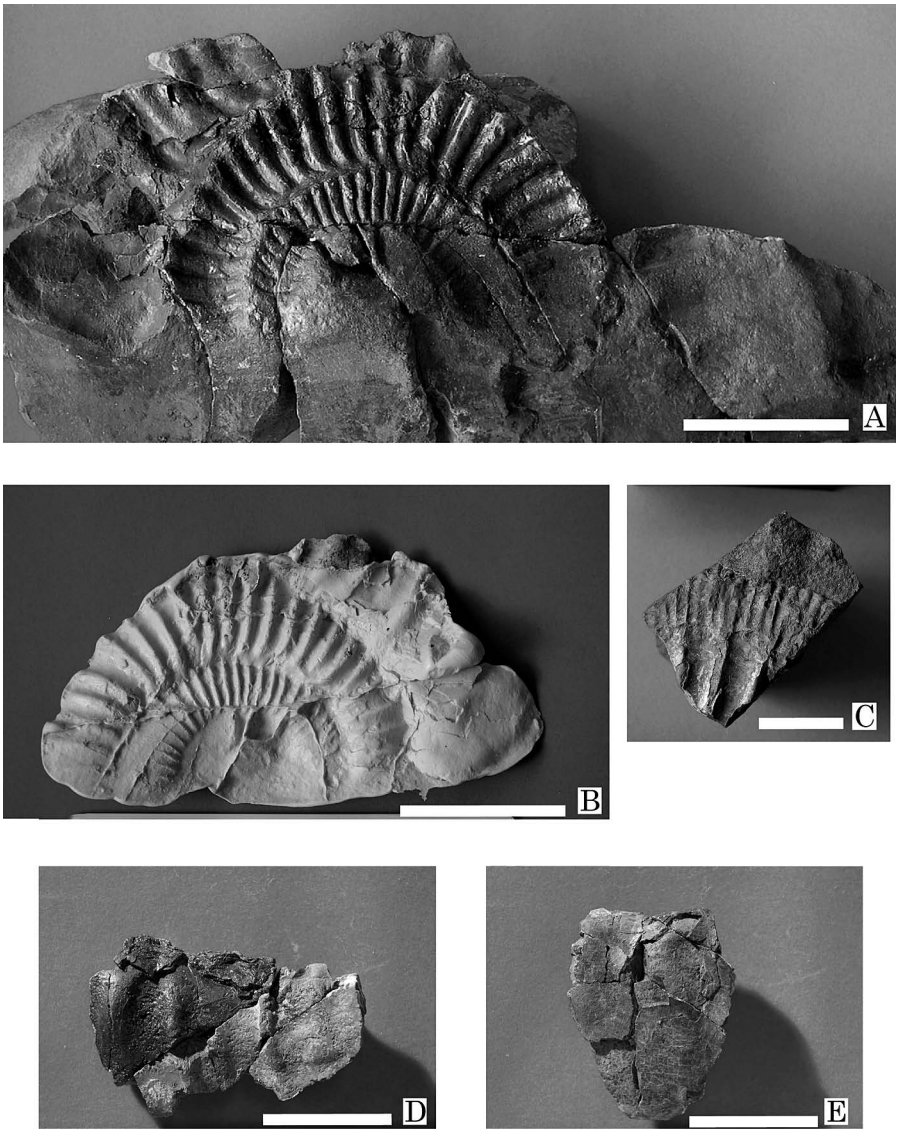

Fig 2. *Perisphinctes* (*Perisphinctes*) cf. *ozikaensis* Fukada (TOYA-Fo-3016) from the Arimine Formation of the Kuzuryu Subgroup, Tetori Group. Scale bars are 5 cm in A & B, and 2 cm in C-E. A, Lateral view of the outer mold; B, Rubber cast from A; C, Lateral view of a part of the whole; D,E, small parts of the last whorl.

A specimen of similar preservation was discovered from a place near the Onegawa River, a tributary of

the Nishiki River, in the township of Miwa, Iwakuni City, Yamaguchi Prefecture (Sato et al., 1986). The specimen is also fragmentary, but large in size (probably about 40cm in diameter), and strong rectiradiate ribbing is seen throughout the development. It is remarkable that the ribs on the preserved last whorls are much stronger, and more distant than those on the inner whorls, suggesting the rapid modification of ornamentation at the end of penultimate whorls.

Geological Age: Though the exact identification is not possible, its resemblance to *Perisphinctes* s.s. suggests the Oxfordian age as do other forms quoted above.

Geological Formation: Arimine Formation.

Genus and Species indet. (Probably immature whorls of *Dichotomosphinctes* sp.)

Fig. 3

Material: Register number TOYA-Fo-3017; A plaster cast taken from the outer cast obtained from a float found in the Higashisakamori-dani ravine, Arimine area. Collected by Mr. Hideo Takayanagi, the former director of the Horikawa-Minami Community Center in Toyama City. The original material is stored in his house (408 Horikawa-cho, Toyama 939-8072, Japan).

Measurements (in mm): Slightly deformed. Measured along the long axis of the deformed ellipse. D 105; UD 45 (UD/D 0.42; H ca.35; W unknown.

Description: Coiling moderately involute (UD/D about 0.4), whorl section presumably elliptical (flattened by compression) with rounded ventral region. Whorls provided with shallow and straight constrictions. Ribbing rather dense (number of primary ribs about 20 per half whorl on the preserved last whorl), primary ribs rectiradiate given rise at the umbilical shoulder without inflection, and generally bifurcated (rarely trifurcated) in acute angles at the middle flank, with sharply defined furcation points; simple ribs accompanied with constrictions. Suture-line unknown.

Observation: The present specimen is in the immature stage as judged by the fact that still senior whorls should be present as indicated by a spiral line at the middle flank which represents the margin of the lost whorl. The lost whorl should be measured about 26 cm, if the ratio of umbilical diameter to diameter (UD/D) is maintained. This seems uncertain, and the coiling could be much less than in the inner whorls.

Comparison: Coiling, whorl shape, and ribbing suggest that this specimen belongs to *Dichtomosphinctes*, which is characterized mostly by sharp, dense and sharply bifurcate ribs and numerous constrictions, as seen in *Dichotomosphinctes kiritaniensis* known from Kiritani and other localities of upper Kuzuryu area. Unfortunately, the present specimen is an outer cast, and it seems that the surface of the shell was more ore less abraded and the sharpness of rib was lost. As described in the previous lines, a bigger specimen of *Perisphinctes* s.s. was procured from the same formation. Because the present specimen is certainly a Perisphinctid, it was first compared to the inner whorls of this *Perisphinctes* s.s., but the following facts precluded this identification: coiling clearly more involute, UD/D being about 0.4 contrary to about 0.6 in above-mentioned *Perisphinctes* s.s. species; as far as the preserved whorls are concerned, ribs are more numerous in the present specimen; general shape especially its ribbing remained unchanged.

Unfortunately, because still outer whorls are lost, and the general state of preservation is too poor, any definitive identification is impossible at this moment.

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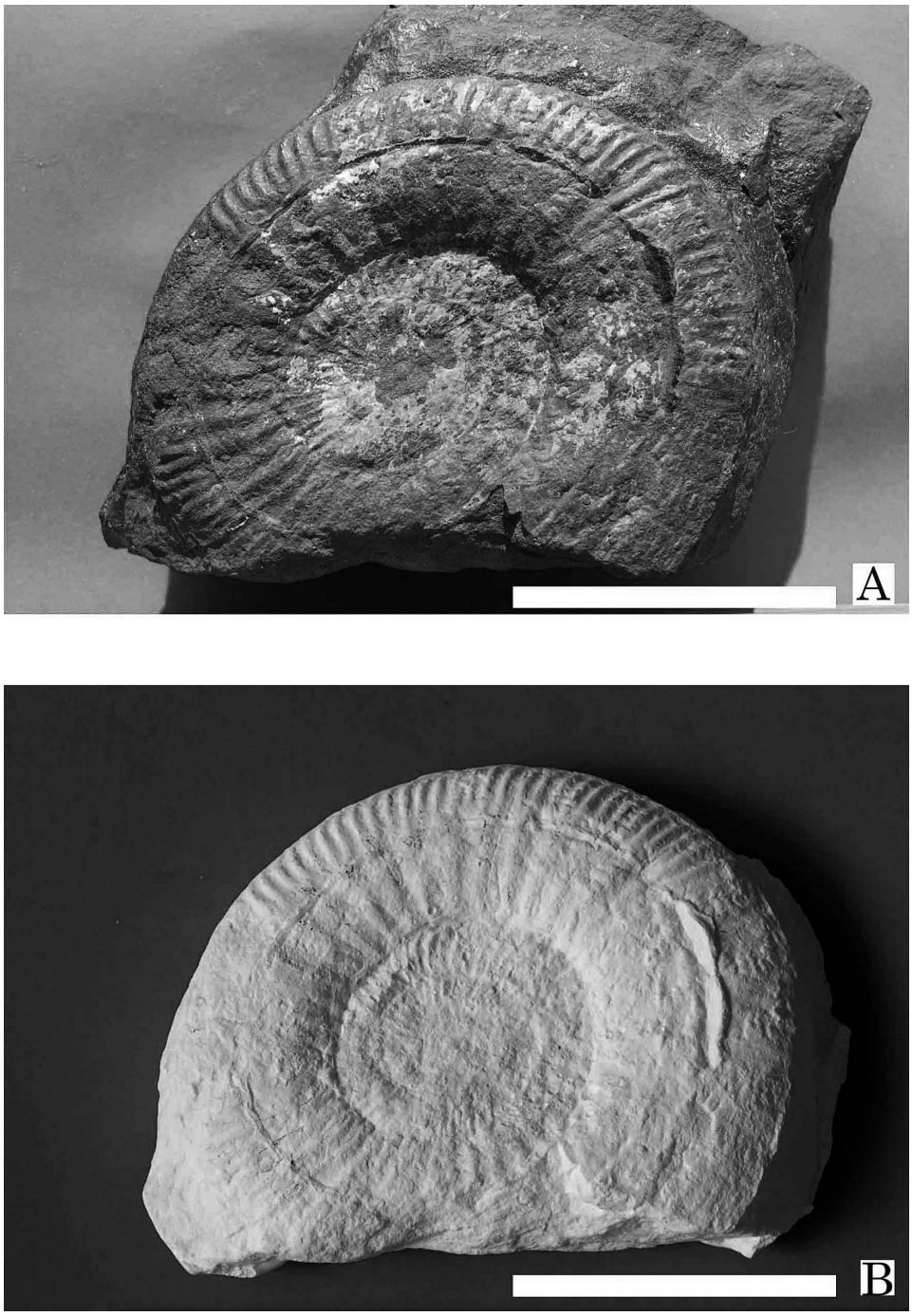

Fig 3. Ammonite of indeterminate genus and species (probably immature whorls of *Dichotomosphinctes* sp.)(TOYA-Fo-3017) from the Arimine Formation, the Kuzuryu Subgroup of Tetori Group. Scale bars are 5 cm. A, Lateral view of the outer cast; B, Plaster cast.

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*　　: in Japanese
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